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Painting Technology and Technique in *Crucifixion* from Pieter Coecke van Aelst's Workshop from the Collection of the National Museum in Warsaw

The *Crucifixion* attributed to Pieter Coecke van Aelst (1502–50)[1] is one of the most precious works of Netherlandish painting at the National Museum in Warsaw[2] (**fig. 1**). However, the question of its attribution has long raised many doubts. In the auction catalogue of 1927, the painting was described as a work by Bernard van Orley (1491/92–1542),[3] and it was only in 1966 that George Marlier attributed it to Coecke.[4] Janina Michałkowa[5] and Jan Białostocki[6] were inclined to attribute it to the Master of the Year 1518, identified with Jan van Dornicke (d. 1527), yet Białostocki eventually returned to the attribution to Coecke.[7] In 2006, Linda Jansen classified the painting as belonging to a group of compositions depicting the same subject – the central fields of three triptychs: from the Rheinlandisches Museum in Bonn, Museum Catharijneconvent in Utrecht and the Fries Museum in Leeuwarden.[8] According to this

[1] Inv. no. M.Ob.590 MNW.

[2] In 1967, the painting was acquired to the NMW collection by proxy of Gaston Palewski (1901–84), closely tied with the Talleyrand-Périgord family, as "compensation" for the return of François Gérard's *Portrait of Talleyrand* (today at the Metropolitan Museum of Art in New York, inv. no. 2012.348) from the Talleyrand family's estate in Żagań (Sagan) and integrated into the NMW collection after the Second World War. It is likely that the *Crucifixion* was purchased in 1927 by the Duke and Duchess of Sagan, Hélie and Anna (née Gould) de Talleyrand-Périgord, based in Paris.

[3] *The Important Art Collection of Dr. John E. Stillwell* [online], auction catalogue, The Anderson Galleries, New York, 1–3 December 1927, p. 70, lot 216, at: <https://bit.ly/2EuSOnS>, [retrieved: 9 April 2018].

[4] Georges Marlier, *La Renaissance flamande. Pierre Coeck d'Alost* (Bruxelles, 1966), p. 189.

[5] Janina Michałkowa, "Nouvelles Acquisitions du Département de la Peinture Européenne 1963–1969," *Bulletin du Musée National de Varsovie*, vol. 11 (1970), no. 2–3, p. 61.

[6] Jan Białostocki, "La *Crucifixion* de Pieter Coecke van Aelst à Varsovie," *Bulletin de l'Institut Royal du Patrimoine Artistique*, vol. 15 (1975), p. 25.

[7] *Malarstwo francuskie, niderlandzkie, włoskie do 1600. Katalog zbiorów*, Jan Białostocki, Maria Skubiszewska, eds, The National Museum in Warsaw (Warsaw, 1979), p. 71, cat. no. 45.

[8] Respectively: inv. no. 92.0639; inv. no. ABMs00107; inv. no. S6071. The scholar considered the Warsaw *Crucifixion* to be an independent work (and not a fragment of an unpreserved triptych) – see Linda Jansen, "Shop

scholar, all of them were the fruit of collaboration of the master and artists from his workshop. She observed that the underdrawing of figural groups in the *Crucifixions* from Warsaw and Utrecht show significant similarities and could have been executed by the same artist; and that analogous similarities appear in the painterly modelling of bodies.[9] However, Jansen also lists discrepancies in the shaping of the elements of the background, which suggests the participation of two different collaborators of the master.[10] Since the landscape in the Warsaw work is painted in a similar manner as the background in the *Crucifixion* from Bonn,[11] Jansen assumes that these parts of the paintings could be attributed to the same workshop member.[12]

In 2016, the painting was subjected to a multifaceted technological analysis involving both invasive and non-invasive methods, within the research project led by Prof. Justyna Olszewska-Świetlik at the Faculty of Fine Arts of the Nicolaus Copernicus University in Toruń (course: Conservation and Renovation of Painting and Polychrome Sculpture).[13] Conservation-related issues concerning the painting also became the subject of Monika Kęsy's MA thesis.[14] The present text brings a summary of this research, additionally set in the context of conclusions reached thus far by art historians.

Collaboration in the Painting of Background Landscapes in the Workshop of Pieter Coecke van Aelst," in *Making and Marketing. Studies of the Painting Process in Fifteenth- and Sixteenth-Century Netherlandish Workshops*, Molly Faries, ed. (Turnhout, 2006), pp. 119–42.

[9] Ibid., pp. 123–24.

[10] Ibid., pp. 125–26.

[11] Ibid., p. 126.

[12] Ibid.

[13] The following examinations have been conducted as part of the research project: photographs of the front with the use of infrared false-colour technique (IRFC), fluorescence under UV light, performed by Adam Cupa. For the examinations under IR light, the digital system for near infrared reflectography with a 780 nm filter was used; and for UV light – a Blacklight Blue lamp with filter with a maximum at 365 nm. Seventeen samples have been extracted (see table 3 and fig. 11); in order to establish the stratigraphy, seven samples (nos: 6, 8, 9, 11, 12, 14, 15) were embedded in "Duracryl Plus" resin (produced by Spofa Dental, Czech Republic) and polished with sandpaper, grit size 300–2000. The samples were extracted by Monika Kęsy, under the supervision of the NMW conservator Iwona Stefańska. Observations of cross-sections were conducted on the Optiphot 2 microscope, magnification 40x and 10x; microscopic photographs of selected samples under visible spectrum (VIS) and UV light were taken. Cross-section samples were examined by Dr Zuzanna Rozłucka. Cross-sections were examined under IR light and in the infrared false-colour technique (IRFC) by Adam Cupa. The VIS and UV photographs were taken with the use of the Nikon Eclipse 600 fluorescence microscope (magnification 100x and 200x), integrated with the Nikon Super HB 1010AF mercury lamp and the standard set of UV 2A filters: EX 330–380 nm, DM 400 nm, BA 420 nm. The IR and IRFC photographs were taken on the Optiphot 2 microscope with halogen light source, with the use of FUJIFILM X-T1 IR camera and filters blocking UV and VIS, letting through radiation beyond 780, 840 and 900 nm for IR and with bandwidth extended to part of visible spectrum (500–700 nm) for colour IR. In the course of pigments and dyes examinations, the following instrumental methods were used: X-ray fluorescence analysis (XRF), with the use of Mini Pal PW 4025 energy-dispersive X-ray spectrometer with helium system (performed by Adam Cupa), energy-dispersive X-ray analysis with the use of electron microprobe (SEM-EDS), scanning electron microscope by LEO Electron Microscopy Ltd, Cambridge, England, type 1430 VP and EDS Quanrax 200 X-ray spectrometer with Xflash 4010 detector by Bruker AXS (Germany) (performed by Dr Grażyna Szczepańska). Microchemical tests were also carried out. For binder examinations conducted by Dr Teresa Kurkiewicz, FTIR analysis was applied with the use of FT-IR spectrometer by Bruker with ATR in the spectral range of 4000–400cm^-1. X-ray photographs were taken and interpreted, independently from the Toruń research project, by Roman Stasiuk – we would like to express our gratitude for his kind sharing of photographs and results. The examinations of pigments, dyes and binders were additionally completed with microchemical analyses conducted by Monika Kęsy.

[14] Monika Kęsy, "Obraz *Ukrzyżowanie* Pietera Coecke'a van Aelsta (1502–50) – analiza technologii i techniki malarskiej jako przyczynek do określenia zmian pierwotnej kolorystyki dzieła," MA thesis, Nicolaus Copernicus University in Toruń, 2017.

The State of Preservation and the Analysis of Painting Technique[15]

Before it was acquired to the NMW collection, the *Crucifixion* must have undergone several conservation treatments;[16] during one of them, the original varnish was removed. The flaking ground and paint were consolidated with the use of water solution of polyvinyl alcohol (PVOH). Ground losses were filled with putty, in which, as revealed by the X-ray, the filler is white lead. Today, it is impossible to determine the dating of these interventions (before 1904?, perhaps between 1927 and 1967). The support was reinforced with an oak cradle system, most likely towards the end of the 19th century (**fig. 2**).[17]

The paint layer is covered by a dense network of cracks; the multiple losses are a result of the flaking of paint. The greatest range of this type of destruction is located on the robes of Mary, both on the blue mantle and the carmine dress. Significant damage is to be found in the background area between the figures of St Mary Magdalene and St John the Evangelist, and on St John's red mantle. Many losses emerged on the painting's edges, caused by an unfortunate mounting of the frame that would wear away the surface of the paint layer. There are numerous retouched spots in the paint layer, applied at an unknown point in time (before 1904?; in the first half of the 20th century?) with the use of zinc white, iron oxide and zinc yellow, iron oxide red and synthetic ultramarine used for glazes, as well as indigo, cobalt blue, cerulean and chromium oxide. The damage has affected around 20 per cent of the surface of the painting (**fig. 3**), which is why a safeguarding layer of wax was applied during a conservation treatment in 1981.[18]

The painting has been given an unoriginal ornamental frame sized 113 × 160 cm, with gildings partly covered with blue glazes.[19]

The support has the shape of a horizontal rectangle sized 93.5 × 138.5 cm with an arched top. Today its thickness is 6 mm.[20] It is built of six vertically joined oak planks of various sizes,[21] cut out from a tree trunk in the radial direction, glued together[22] (**fig. 4**). The wood was derived

[15] See table 1.

[16] Information on past conservation treatments is stored by the Archive of the National Museum in Warsaw (further referred to as: ANMW), conservation documentation (dok. kons.) no. 21/79. Information regarding materials employed for the retouching of the paint layer and for the description of its state of preservation is given on the basis of our research and the X-ray photographs taken by Roman Stasiuk.

[17] The cradling consists of 26 broad planks vertically glued, parallel to the grain. They cover c. 80 per cent of the back's surface. In the planks, holes are cut out into which seven movable planks are inserted, arranged perpendicularly to the vertical ones. It can be assumed that before the cradling was installed, the original planks and wood cracks were consolidated (glued) and the back was thinned or only levelled up.

[18] ANMW, dok. kons. no. 21/79.

[19] It is not integrally connected with the painting, as it overlays the front; it is attached to the back by means of tin plates that function as grips that rest on the cradling.

[20] The support size given in the old publications differs slightly from the size measured in the course of the present examinations. See *Malarstwo francuskie...*, op. cit., p. 70; Hanna Benesz, Maria Kluk, *Early Netherlandish, Dutch, Flemish and Belgian Paintings 1494–1983 in the Collections of the National Museum on Warsaw and the Palace at Nieborów. Complete Illustrated Summary Catalogue* (Warsaw, 2016), vol. 1, p. 136, cat. no. 141, fig. 141.

[21] The width of the planks measured from left to right, respectively: 26 cm, 22.5 cm, 25 cm, 27 cm, 14.5 cm, 23 cm – see Tomasz Ważny, "Analiza dendrochronologiczna obrazu *Ukrzyżowanie* Coecke van Aelsta (1502–1550), sprawozdanie z badań", Chair of Painting Technology and Techniques, Studio of Dendrochronological Tests at the Institute of Heritage Protection and Conservation, The Nicolaus Copernicus University in Toruń, 2018 (unpublished).

[22] See ANMW, dok. kons. no. 21/79; Ważny, op. cit. Analysed were digital photographs of cleansed plank edges with transversal cross-sections of wood. The width of annual growths was measured with the use of Cybis CooRecorder – Image Coordinate Recording Program, Version: 2.3.13 (Larsson 2003). For wood testing, specialised software was used: TSAPWin (Rinn 2005–18) and DENDRO for WINDOWS 10 (Tyers 2018).

from various trees from the species called Baltic oak, originating from the areas situated east or north-east of the modern-day territory of Poland. Only the planks numbered 2 and 3 were cut out of one and the same tree. The youngest preserved growth dates to 1509 (taking into account recorded, yet not measured growth rings). Sapwood was completely removed in the course of wood processing. The reconstruction of the layer (in this part of Europe containing minimum nine growth rings) permits to determine that the wood originates from a tree felled after 1517. In the 16th and 17th century, the average period of seasoning of wood that was used in northern-European painting was two to eight years. With the shortest time of seasoning and transport, the year 1520 would be the earliest possible date of the painting's creation. With the average thickness of the missing sapwood (15 growth rings) and the average period of seasoning (five years), the dating of around or after 1529 would seem the most likely.[23]

The support, previously sized with a solution of animal glue,[24] had been grounded before it was given the original frame. Such order is suggested by the presence of the ground layer reaching the very edges of the support and the absence of thickened areas along the frame. Such thickenings would have formed if the support had been simultaneously grounded and framed. White chalk and a small amount of white lead was used as the white ground's filler, and animal glue as binder.[25] White lead was added to the top layers in order to give the ground a lighter tone. Its minimum thickness is 100 μm; it was laid warm, in several layers.[26] The final layers could have been applied cold, with the use of a plank, in order to achieve a smooth surface.[27]

The composition's underdrawing[28] was executed with the use of a semi-round brush and bone black in water-based binder. The underdrawing shows an effortless, vibrant line that testifies to the mastery of the artist. In several areas, it does not correspond with the final painted depiction. The process of the search for proper form can be observed in the arrangement of the legs and arms of Christ, the position of St John's foot (**fig. 5**), the shapes of folds

[23] Ważny, *Analiza dendrochronologiczna*..., op. cit.

[24] See Antoni Ziemba, *Sztuka Burgundii i Niderlandów*, vol. 2: *Niderlandzkie malarstwo tablicowe 1430–1500* (Warsaw, 2011), p. 436. For conservatorial reasons, no samples involving the support were taken, which prevented us from identifying the type of sizing.

[25] The conservatorial documentation suggests that the ground tests conducted at the NMW in 1979 confirmed the presence of gesso instead of chalk. However, the 1979 catalogue mentions chalk-glue ground. The latest tests confirm the presence of chalk. The chalk-glue ground was typical for that artistic region, while gesso grounds were chiefly employed in Italy and Spain. See ANMW, dok. kons., no. 21/79; *Malarstwo francuskie*..., op. cit., p. 70; Ziemba, op. cit., p. 439.

[26] By reason of the absence of evidence containing the full cross-section of the ground, it is difficult to estimate its actual thickness. However, the analysis of samples suggests that it was not thinner than 100 μm. The ground could have been applied warm, as suggested by the presence of air bubbles in its lower part, visible in cross-sections of the samples taken from the painting.

[27] The exact method of smoothing up the ground is not clear, for there are no traces of the tool left. The ground's thinness suggests that the treatment could have been performed with a plank, involving cold application of the final layers. After they dried up, the surface was delicately polished.

[28] The examinations of the underdrawing in the Warsaw *Crucifixion* and other works by Pieter Coecke van Aelst were performed by a team of researchers: Linda Jansen, Molly Faries and Maximiliaan P.J. Martens within the project *Antwerp Painting Before Iconoclasm 1480–1566. A Socio-Economic Approach*. The results were presented in Jansen's doctoral dissertation (University in Groeningen) dedicated to the workshop practice of Van Aelst, based on the team's examinations of works attributed to the artists. See also: Linda Jansen, "The Last Supper as a Starting Point for the Study of the Workshop Practices in the Group Pieter Coecke van Aelst," in *Jerome Bosch and its Entourage and Others Studies*, Hélène Verougstraete, Roger van Schoute, eds (Leuven, 2003), pp. 165–74; ead., *Shop Collaboration*..., op. cit., pp. 119–42; ead., "Serial Products in the Workshop of Pieter Coecke van Aelst:

of the mantle of Mary and St John and the perizoma of Jesus (**fig. 6**). In the underdrawing of fabric folds, Coecke's signature trait appears – an S-shaped line with a hook-like ending that outlines the creases and hollows of the fabric (**fig. 7**). The faces were outlined with the use of a round brush. All figures have prominent lips (half-open in the case of St Mary Magdalene) and the brow line characteristically joining the bridge of the nose. The free and effortless underdrawing and the presence of the artist's corrections in the paint layer suggest the hand of Coecke himself. No traces of transferring the composition from a stencil (cartoon) have been identified; perhaps the artist worked directly on the support and only helped himself by looking at the design. The underdrawing is limited to the figures and several elements of the composition in the foreground. No traces of underdrawing have been identified in the background areas.

The oil isolation layer was applied onto the ground after the underdrawing had been completed. The binder infiltrated the absorbent chalk ground, which is clearly visible in the cross-sections of samples. Its yellow fluorescence can be observed under UV light. The isolation was supposed to prevent the migration of the binder from the paint into the absorbent ground, and also to increase the ground's endurance by the formation, under the agency of oil, of water-insoluble calcium soaps.[29]

The painterly modelling was executed in the multi-layered technique including underpainting and glazes. Usually, these were two or three layers of paint of maximum thickness of 70 μm. In the course of analyses, oil binder has been identified.[30] Most probably, the glaze layers also contained natural resins, and the underpainting layers – water-in-oil emulsions.[31] The colour palette includes pigments and organic dyes typical for the period. In the course of examinations, the following pigments and dyes have been identified: white lead, lead-tin yellow, natural yellow, red and brown iron oxide pigments, organic yellow, umber, minium (red lead), vermilion, natural azurite, malachite, copper green, bone black, vegetable black, organic red (madder; kermes or carmine).[32]

A Working Hypothesis," in *La peinture ancienne et ses procédés : copies, répliques, pastiches*, Hélène Verougstraete et al., eds (Leuven, 2006), pp. 173–80; Maryan W. Ainsworth, "Pieter Coecke van Aelst as a Panel Painter," in *Grand Design. Pieter Coecke van Aelst and Renaissance Tapestry*, Elizabeth Cleland, ed., exh. cat., The Metropolitan Museum of Art, New York, 2014–15 (New York, 2014), pp. 22–34. The latest analyses under IR light conducted by Polish scholars have confirmed theories proposed in the listed publications.

[29] See Justyna Olszewska-Świetlik, *Technologia i technika gdańskiego malarstwa tablicowego drugiej połowy XV wieku* (Toruń, 2005), p. 220.

[30] The catalogue description of the object (see *Malarstwo francuskie...*, op. cit., p. 70) informs that the painterly layer was executed in tempera with resin glazes. The latest analyses have not confirmed the presence of egg white binder. Oil binder gives characteristic fluorescence stimulated by UV radiation on the cross-sections of samples.

[31] It cannot be excluded that egg white or natural resin was used. Minimal amount of samples of minimal size were extracted for the study, on the verge of resin's traceability, and moreover, the introduction of conservation materials impedes the course of analyses.

[32] Two types of red organic dyes have been observed on cross-sections – madder and carmine or kermes, which were differentiated on the basis of their fluorescence under UV light; see Justyna Olszewska-Świetlik, Zuzanna Rozłucka, "Badania czerwonych laserunków metodą mikroskopii fluorescencyjnej," *Acta Universitatis Nicolai Copernici, Zabytkoznawstwo i Konserwatorstwo*, vol. 34 (2005), pp. 141–60. For the subject of manufacture and use of carmine, madder and kermes, see, i.a., Jo Kirby, Raymond White, "The Identification of Red Lake Pigment Dyestuffs and a Discussion of their Use," *National Gallery Technical Bulletin*, vol. 17 (1996), pp. 63–65; Jo Kirby, Marica Spring, Catherine Higgitt, "The Technology of Red Lake Pigment Manufacture. Study of the Dyestuff Substrate," *National Gallery Technical Bulletin*, vol. 26 (2005), pp. 71–86; Olszewska-Świetlik, *Technologia i technika gdańskiego...*, op. cit., pp. 233–42; ead., *Technologia i technika malarska wybranych nowożytnych epitafiów z Bazyliki Mariackiej w Gdańsku* (Toruń, 2009), pp. 112–13; ead., *Gdański warsztat malarski schyłku XVII i w XVIII wieku na przykładach wybranych portretów przedstawiających protestanckich duchownych* (Toruń, 2010), pp. 52–53.

The painterly modelling started with the brown paint underpainting of the area of the ground in the foreground.[33] Then, the painter worked on the figures of Mary and St John (the brown layer has been found under part of their robes) (**fig. 8**), the figures of Christ and St Mary Magdalene, and details of the landscape in the foreground. The grass behind the cross was painted after the figures and trees. Then, the view of the town and mountains was completed. Paint layers in the sky (painted with the use of whites and blues, likely in the "wet-on-wet" technique) slightly overlay the modelling of figures (**fig. 9**), which means that they were executed later. The last stage consisted in the introduction of corrections (*pentimenti*): the shape of the bottom part of Mary's mantle and sleeve was changed, the arrangement of Christ's arms and legs was modified, his face and perizoma were slightly corrected as were the layout of St John's robe and the position of his right leg (fig. 5). The outline of the bone lying at the bottom of the Cross (identified as a shoulder blade), present in the underdrawing, has been omitted in the painted layers (fig. 7).

The modelling of skin began from the application of a thin layer of pink underpainting, mixed from white lead with an addition of red (probably minium, vermilion and madder) and iron oxide yellow. Shades were marked with medium-opacity brown, while lighter areas were achieved owing to the addition of a larger amount of white lead to pink (high-opacity paint, visible brushwork). The lightest parts are impastoed in almost pure white paint. Brown lines delicately outline facial details: eyebrows, eye contours, nose, mouth and contours of hands and bare feet. The light, cool-toned skin of both Mary and St Mary Magdalene are livened up by warm-toned glazes of red applied on their cheeks; St John's complexion displays a warmer tone due to the use of a greater amount of brown. The modelling of the shades of the body of Christ was rendered by means of a blueish hue of pink, with an admixture of black and brown. Hair was underpainted flat with a brown local colour; the artist first deepened shades, and then painted single hairs with a lighter brown. He applied paint with a thin brush, impastoing, which added depth to the modelling. The blood dripping from Christ's wounds was painted using madder and vermilion.

The blue colour of Mary's mantle (the identified pigment is natural thick-grained azurite, grains sized 5–20 μm) was applied on the brown underpainting, and in the bottom part, the layers applied earlier under the background (depiction of the ground) were used. Shades were achieved due to an addition of vermilion, black and iron oxide red. In the lower layers, the painter likely added *cerrusa* (white)[34] to local colour – due to the content of chalk, it was more opaque than white lead. Underneath the left sleeve of Mary's mantle, one can see a dark red underpainting, which contains natural iron pigments: minium, umbre, vegetable black and a minor addition of chalk. It may be linked with the artist's corrections, that is, the shifting of Mary's sleeve to the right. Highlights were achieved by adding an adequate amount of white lead to azurite. The examinations have not delivered a clear answer to the question as to how the bottom part of Mary's robes was painted. Possibly, the painter may have initially added a

[33] Such order of procedures is suggested by the analysis of layers below the surface and samples.

[34] *Cerrusa* is a 1 : 1 mixture of lead white and chalk; see Théodore Turquet de Mayerne, *Pictoria Sculptoria et qua subalternarum atrium spectantia*, 1620, The British Library, inv. no. Sloane Ms 2052. See *Quellen für Maltechnik während der Renaissance und deren Folgezeit (XVI–XVIII Jahrhundret) in Italien, Spanien, den Niederlanden, Deutschland, Frankreich und England nebst dem De Mayerne Manuskript*, Ernst Berger, ed. (München, 1901), pp. 118–19; Olszewska-Świetlik, *Gdański warsztat...*, op. cit., p. 49.

blue layer of local colour (natural azurite), which seems to testify to his intention of covering here the inner gown by the mantle's tail. In this layer, white was added for highlights and black for shades. In the course of his work, the painter may have changed his mind and applied a carmine glaze with an addition of white in highlights, achieving dark red-purple colour. However, another possibility cannot be excluded, either. The blue local colour put under the red glaze could have been the original intention of the artist. For glazes, he employed two types of organic red: warmer madder and cool purplish kermes or carmine.[35] The top part of this robe, much lighter, was painted in azurite, without any underpainting. First, he applied red local colour (iron oxide red with minium[36] and umber, vegetable black and a small admixture of chalk, which may be suggested by the underpainting under the blue sleeve of the mantle).[37] For shades, he added black, and for highlights – white. He put an organic red (madder) glaze upon the chiaroscuro treatment.

The artist underpainted St John's warm-red robe in reddish brown obtained from a mixture of vermilion, minium, bone black and tin-lead yellow. In shades, he laid a layer consisting of minium and iron oxide red, and only on top of it – a red glaze. He employed two types of organic red: madder and, in cooler-toned areas, kermes or carmine. For mid-shades and highlights, he used minium with an adequate addition of white which endowed the red paint with warmer tone. He finished the part with a red (madder) glaze (**figs 10, 11**) (see table 4).

On the red mantle of St Mary Magdalene, the artist laid local colour – minium and vermilion. In shades, he added black, and in lights – white. He covered the part with a red glaze of madder. He deepened shades by reapplying the glaze layer multiple times, with a small addition of black. The yellow-red inner garment of St Mary Magdalene is underpainted in shades of grey. Midtones and highlights are executed with the use of a mixture of vegetable black with an addition of white (*cerrusa*). Shades were applied upon the underpainting that was darker; it involved the use of bone black, tin-lead yellow and white (*cerrusa*). Then, local colour was laid: a mixture of minium, tin-lead yellow, white lead and a natural brown iron oxide pigment. The modelling was made with the use of reddish yellow paint consisting of organic yellow with an addition of minium and white lead. In highlights, more white was added to the basic colour. The green sleeves of St Mary Magdalene's robe were painted mainly in malachite green. He would add white lead for highlights and black for shades. He finished with a green-blue glaze on the basis of copper pigments.

The green grass behind the Cross was also painted with the use of malachite and copper greens, with a greater amount of white and an addition of yellow. In shades, he also added azurite and black. The warmer-toned green grass was painted with the use of a mixture of green, yellow and red. The painter, intending to achieve brown hues, used mixtures of various iron oxide pigments (e.g., for the cross beams), sometimes with an addition of white or black (in the foreground). Trees and bushes were modelled on the basis of an ochre or brown underpainting, in malachite green with an addition of white or yellow, and the leaves were depicted by means of single brushstrokes. The highlights display more texture, with visible strokes of a round brush. The grass blades painted by single impasto strokes are remarkable.

[35] See n. 33.

[36] Sample no. 9.

[37] Sample no. 6.

Fragments of bones lying under the cross were rendered with great attention to detail; browns and yellows were used. In the background, there appear, among others, impastoed figures of soldiers and animals. The town view on the right side, in the middle ground, was also impastoed in a blue-green tonality.

The view of the town and mountains in the background is maintained in a blue tonality (natural azurite was employed) with an addition of white lead in highlights, on a brown underpainting. Elements of architecture were emphasized with minium red. Details of buildings were rendered by means of black or blue lines.

The sky was painted in white lead and natural azurite. The artist painted clouds "into" wet white parts with dynamic hand gestures (using a mixture of white and blue), and used a similar technique painting white clouds on the blue background. All of this was impastoed – the clearly discernible brushstrokes run in various directions.

Conclusions

The latest research enabled to identify and describe in detail the technology and technique as well as materials used for the *Crucifixion* from the National Museum in Warsaw. Do these results have impact on the question of the painting's attribution and dating?

In 2006, Linda Jansen proposed a thesis on the collaboration of two painters as the authors of the work. The scholar suggested that the author of the figural scene in the foreground was a highly qualified artist working in Pieter Coecke van Aelst's workshop (yet did not clarify whether or not she identified him with Coecke), while the landscape would have been painted by another artist employed in this workshop.[38] Numerous examples of this model of collaboration in the workshops of 16th-century Antwerp masters could be cited.[39] The latest research confirms Jansen's observations. The painting process began with an underdrawing executed directly on the grounded support. It could be described as effortless and free-mannered. The noteworthy corrections suggest that the composition is an original idea of the artist. Most likely, the artist did not employ a model drawing (see table 2). Moreover, the qualities of the underdrawing – the free, vibrant line executed in a liquid material, and the presence of alterations introduced in the paint layer – display similarities with Coecke's compositional sketches and his working methods.[40] In particular, the underdrawing of faces is characteristic: the line of eyebrows joins the bridge of the nose with distinctly outlined nostrils, while the slightly opened mouth looks fleshy.[41] Similarly rendered facial traits can be found in other paintings linked with the Antwerpian master.[42]

[38] Jansen, *Shop Collaboration...*, op.cit., pp. 124–26.

[39] Piotr Borusowski, Aleksandra Janiszewska, *W warsztacie niderlandzkiego mistrza. Holenderskie i flamandzkie rysunki z kolekcji Muzeum Narodowego w Warszawie / In the Workshop of a Netherlandish Master. Dutch and Flemish Drawings from the Collection of the National Museum in Warsaw*, Antoni Ziemba, academic ed., exh. cat., The National Museum in Warsaw, 2017 (Warsaw, 2017); Ziemba, op. cit.

[40] I.a., *St Luke Painting Madonna*, c. 1530–35, Musée des beaux-arts, Nîmes, inv. no. IP1678; *Holy Family*, c. 1530–35, Museum Leuven, inv. no. S/26/C.

[41] Jansen, *Serial products...*, op. cit., p. 177.

[42] See, i.a., *Head of Man Looking Upwards* (fragment of a tapestry cartoon for the series *Story of St Paul*, Collection of Philip Taaffe, New York). See *Grand Design...*, op. cit., p. 157, cat. no. 36 as Pieter Coecke van Aelst or his workshop; Stijn Alsteens attributes the drawing to the master and his workshop, see Stijn Alsteens, "Drawings of Pieter Coecke van Aelst," *Master Drawings*, vol. 52, no. 3 (2014), pp. 338–39, cat. no. B5, fig. 70.

In the background part, no traces of underdrawing have been found. Jansen pointed out that this compositional scheme of a city panorama was universally employed in Antwerp at that time.[43] They were copied after model sketches or *ricordi* of already existing compositions, used by various workshops. This would explain the lack of underdrawing – the painter would copy a model that he held in front of his eyes or knew by heart due to multiple repetitions. Since the landscape was usually painted after the application of brown colour in the foreground and the modelling of figures, in many spots individual painted layers overlay each other's borders. This, too, suggests a collaboration of two painters and supports Jansen's thesis.

While dating the Warsaw *Crucifixion*, scholars have so far taken into account two arguments. Białostocki pointed at the similarities to the today-lost composition of the Master of the Year 1518 from Haus Caen.[44] He emphasized the *Crucifixion*'s "simplicity and condensed expression," and the limited number of figures, which indicated that it was painted when the style of "Antwerp Mannerism" was fading.[45] However, the main premise for dating has been, so far, the character of the landscape, in which Hanna Benesz saw reminiscences from Pieter Coecke's journey to Italy and Turkey.[46] This would mean that the painting could only have been finished after 1534, when the artist returned to Antwerp. However, as we have already pointed out, the elements used in the composition of the landscape belonged to standard patterns present in Antwerpian painting at least from the 1520s.

In order to establish possible dating of the work, we will employ the stylistical chronology of the master's oeuvre proposed by Maryan W. Ainsworth. Despite the absence of the master's dated or signed works as orientation points that would permit to follow his stylistical development and evolution of technique, the scholar chose two well-documented pieces: the early *Last Supper* of 1527[47] and *Descent from the Cross* of c. 1540–45.[48]

The first stage of Cocke's oeuvre concentrates around the *Last Supper* and encompasses the works completed in the 1520s.[49] Their characteristic features include the presence of grey imprimatura laid on white ground.[50] The master executed the underdrawing using a

[43] See collaborator of the Master of Cardinal Wolsey, *Crucifixion* in the Arenberg's Missale, private collection, fol. 68v; unknown artist from Antwerp, *View of Jerusalem*, drawing, c. 1520–30, Staatliche Museen zu Berlin, Kupferstichkabinett, inv. no. KdZ 5525; Herri met de Bles, *Way of the Cross*, c. 1535–36, Princeton University Art Museum, inv. no. 50-1; view of Jerusalem in the sketchbook from the Kupferstichkabinett in Berlin, inv. no. 79 C 2, fols 31v, 32r; artist from the circle of Pieter Coecke van Aelst, *Crucifixion*, drawing, 1536, Staatliche Museen zu Berlin, Kupferstichkabinett, inv. no. KdZ 13280.

[44] Undated in literature; see Marlier, op. cit., p. 188; See Jan van Dornicke, *Crucifixion Triptych*, c. 1520, private collection, see Justus Müller Hofstede, "Jan van Dornickes Kreuzigungsaltar ein Meisterwerk der Antwerpener Malerei vor Pieter Bruegel d. Ä.," *Wallraf-Richartz-Jahrbuch*, Bd 52 (1991), pp. 151–61.

[45] *Malarstwo francuskie...*, op. cit., p. 71.

[46] *Sztuka cenniejsza niż złoto. Obrazy, rysunki i ryciny dawnych mistrzów europejskich ze zbiorów polskich*, Anna Kozak, Antoni Ziemba, eds, exh. cat., The National Museum in Warsaw, 1999 (Warsaw, 1999), p. 144, cat. no. 37; for the journey; see, e.g., Annick Born, "Pieter Coecke van Aelst and the Roads eading to Rome," in *Culture figurative a confronto tra Fiandre e Italia dal XV al XVII secolo*, Anna De Floriani, Maria Clelia Galassi, eds (Milan, 2008), pp. 94–105.

[47] The Duke and Duchess of Rutland Collection, Belvoir Castle, Granthem, Great Britain; see *Grand Design...*, op. cit., p. 49, cat. no. 5.

[48] Museu Nacional de Arte Antiga, Lisbon, inv. no. 112.

[49] *The Adoration of the Magi*, Diamont Collection; see *Grand Design...*, op. cit., pp. 36–37, cat. no. 1; *Lovers Surprised by a Jester and Death*, private collection; see ibid., p. 55.

[50] Ainsworth, op. cit., pp. 26–27.

brush and liquid material. It is rather poorly visible under IR light, but legible in direct observation.[51] The composition's contours are based on quickly and smartly applied lines with looped endings; sporadically, parallel and cross-hatching is used for shades. Basing on the example of *Resurrection* of c. 1530,[52] Ainsworth determines how the artist painted complexions in that period – his brushstrokes are brave, if not impastoing. A change occurred in the early 1530s,[53] perhaps induced by Coecke's experience with the preparation of tapestry cartoons.[54] In *The Adoration of the Magi* of c. 1530,[55] Ainsworth observed a new method of modelling complexion – the painter applied very thin and delicate paint layers without visible texture.[56] In the works from this period[57] the lack of previously employed imprimatura can be observed. The underdrawing executed with a brush or pen and liquid material containing charcoal is visible under IR light. The easy-mannered drawing suggests that the master applied it directly onto the ground, without a stencil. It is further implied by numerous modifications in the underdrawing itself and differences between the sketch and the final painting. The third stage, according to Ainsworth, began after Coecke's return from the journey to Italy and Constantinople and is characterized, among others, by the presence of emphasized underdrawings with extensive use of parallel and cross-hatching to mark the modelling of the figures. The *Descent from the Cross* from Lisbon is, according to her, an example of inspiration from the art of Giulio Romano, to which Coecke was exposed during his stay in Italy.[58]

The technical and stylistical analysis of the Warsaw *Crucifixion* indicates that the painting was completed in the second stage of Pieter Coecke van Aelst's career. The black underdrawing in water-based paint is clearly seen under IR light. There is no hatching. The rather thick lines are applied in a manner that shows the artist's mastery and fast pace of work. The painting's composition was altered by the author both in the stage of the underdrawing and in the process of painting (*pentimenti*). The complexions were modelled by laying semi-opaque, smooth layers almost devoid of visible brushwork. These qualities suggest, in accordance with the periodization proposed by Ainsworth, the dating of the work to the early 1530s: c. 1530–33.[59] These conclusions coincide with the results of the dendrochronological analysis discussed above which indicates that the painting could have been delivered around or after 1529 at the earliest. This thesis is also confirmed by the lack of grey imprimatura, which was, as stated

[51] *Christ Carrying the Cross* (c. 1520–25, Kunstmuseum Basel, inv. no. 1250) has a black chalk underdrawing, yet stylistically resembles other works from the discussed group; see ibid., p. 41, cat. no. 2; Ainsworth, op. cit., p. 27.

[52] Staatliche Kunsthalle Karlsruhe, inv. no. 153.

[53] The year 1533 – when Coecke left Antwerp to return in 1534 – should be considered the boundary. Ainworth chooses not to draw such a distinct line.

[54] See Ainsworth, op. cit., p. 30; A. Born, *Pieter Coecke...*, op. cit., pp. 97–98.

[55] Koninklijke Musea voor Schone Kunsten van België, inv. no. 386.

[56] Ainsworth, op. cit., p. 31.

[57] *Holy Family*, c. 1530–35, Museum Leuven, inv. no. S/26/C; *St Luke Painting Madonna*, c. 1530–35, Musée des beaux-arts in Nîmes, inv. no. IP1678.

[58] Ainsworth, op. cit., p. 34.

[59] Ibid., pp. 31–32. In the years 1533–34, Coecke went on a journey to Constantinople; see Elizabeth Cleland, "Recognizing Pieter Coecke van Aelst," in *Grand Design...*, op. cit., p. 3; Paul Fierens, *L'Art en Belgique du Moyen Âge à nos jours* (Bruxelles, [1947]), p. 220.

by Ainsworth, gradually abandoned by Coecke in the 1530s.[60] The grey underpainting of the yellow-red robe of St Mary Magdalene would be its far echo.[61]

The examinations conducted at the Chair of Painting Technology and Technique at the Faculty of Fine Arts of the Nicolaus Copernicus University in Toruń and their confrontation with observations of Linda Jansen and Maryan W. Ainsworth have confirmed the theories of both scholars. They have also permitted a more precise dating of the Warsaw *Crucifixion* and as such will provide a starting point for future research on its attribution.

Translated by Karolina Koriat

[60] Ainsworth, op. cit., p. 30.

[61] Ibid., pp. 26–27.

Table 1
Crucifixion from the workshop of Pieter Coecke van Aelst – the use of materials

Technological layer		Material
Support		oak planks
Glue ground		animal glue
Ground	**colour**	white
	filler	chalk $CaCO_3$, lead white $2PbCO_3 \times Pb(OH)_2$
	adhesive	animal glue
Underdrawing		contour drawing, black, applied with a brush
Isolation layers		oil
Paint layer	**adhesive**	oil, natural resin
	underlayers	local colour
	white	lead white $2PbCO_3 \times Pb(OH)_2$
		cerrusa white $2PbCO_3 \times Pb(OH)_2 + CaCO_3$
	black	bone black $Ca_3(PO_4)2CaCO_3$
		vegetable black
	red	vermilion HgS
		natural iron oxide red Fe_2O_3
		organic red – madder lake *Rubia Tinctorium L*
		organic red – kermes (?) or carmine lake (?)
		minium Pb_3O_4
	blue	natural azurite $2CuCO_3 \times Cu(OH)_2$
	green	malachite $CuCO_3 \times Cu(OH)_2$
		verdigris
	yellow	lead tin yellow Pb_2SnO_4
		natural iron oxide yellow $Fe_2O_3 \times nH_2O$
		organic yellow lake
	brown	brown iron oxide pigments

Table 2
Changes in the underdrawing and *pentimenti*

	Underdrawing	***Pentimenti***
Christ	– Christ's legs moved to the right – altered arrangement of the feet – redrawn folds on the perizoma	– changed location of the head – altered arrangement of the arms – altered trunk of the body – relocated feet
Mary	– altered shapes of the mantle folds and the left side of the head – changes in the size of the mantle, left side, arm on the elbow level	– repainted Mary's mantle, left bottom part, sleeve and arm
St John the Evangelist	– moved left leg (right side of the painting) – altered arrangement of folds on the mantle (left upper side) – altered coiffure (right upper part)	– *pentimenti* around St John's head
St Mary Magdalene	– exploration of the face's shape – exploration of the arrangement of the eyes and lips – exploration of the coiffure	
Background	– present underdrawing of a shoulder blade, omitted in the final painting	

Table 3
Test results of samples' ingredients (fig. 12)

Sample no.	Characteristics of the samples*	Ingredients
1	red, shade, *pentimenti* of Mary's robes	iron oxide red, chalk-glue ground with an addition of white lead $2PbCO_3 \times Pb(OH)_2$
2	blue, shade, underneath the red of Mary's robe	azurite, iron oxide red, chalk-glue ground
3	white ground	chalk-glue ground with an addition of white lead $2PbCO_3 \times Pb(OH)_2$
4	blue, shade, original, Mary's mantle border	azurite, iron oxide red, white lead
5	blue/green, shade, Mary's mantle	azurite, iron oxide red, white lead, chalk-glue ground with an addition of white lead $2PbCO_3 \times Pb(OH)_2$
6	blue, shade, sleeve, *pentimenti* of Mary's mantle	retouched spots: secondary varnish, synthetic ultramarine (sodium aluminosilicate), indigo, white lead, vegetable black, white lead, oil original: natural azurite, bone black, natural iron oxide red pigments, minium, umber, *cerrusa* (white), oil
7	blue, highlight, sleeve of Mary's mantle	azurite, iron oxide red, azurite, chalk-glue ground with an addition of white lead $2PbCO_3 \times Pb(OH)_2$
8	blue, shade, *pentimenti* of Mary's mantle	retouched spots: secondary varnish, synthetic ultramarine (sodium aluminosilicate), indigo, white lead, natural azurite, white lead, oil original: natural azurite, iron oxide red, vermilion, *cerrusa* (white), vegetable black, oil, chalk-glue ground with a small addition of white lead, saturated with oil
9	red, shade, Mary's robe	secondary varnish organic red, madder lake, substrate: $Al(OH)_3$, white lead, vegetable black, bone black, chalk, iron oxide red, minium, copper pigment, *cerrusa* (white), oil
10	red, shade, St Mary Magdalene's mantle	iron oxide red, minium, vermilion, white lead, chalk-glue ground with an addition of white lead $2PbCO_3 \times Pb(OH)_2$

11	yellow, shade, St Mary Magdalene's robe	secondary varnish original protein varnish***, organic yellow (lake substrate: $Al(OH)_3$), minium, white lead, bone black, lead tin yellow, *cerrusa* (white), vegetable black, oil
12	red, shade, St John the Evangelist's mantle	organic red, likely kermes or carmine lake?, white lead, organic red, likely madder, substrate: $Al(OH)_3$, natural iron oxide red, minium, malachite, vermilion, tin-lead yellow, vegetable black, *cerrusa* (white), bone black, chalk-glue ground with a small addition of white lead, saturated with oil
13	red, shade, St John the Evangelist's robe	iron oxide red, minium, chalk-glue ground with an addition of white lead $2PbCO_3 \times Pb(OH)_2$
14	green, shade, St Mary Magdalene's robe	retouched spots: chromium oxide, brown pigment, oil original: malachite, white lead, bone black, oil, chalk-glue ground with a small addition of white lead, saturated with oil
15	green, shade, grass	natural iron pigments, verdigris, white lead, chalk, bone black, vegetable black, minium, natural azurite, organic red lake, *cerrusa* (white), oil, chalk-glue ground with a small addition of white lead, saturated with oil
16	white, highlight, perizoma	white lead
17	blue, sky	retouched spots: indigo, cerulean blue, cobalt blue, zinc white original: azurite, white lead, iron oxide red, chalk-glue ground

* Samples nos 1–5, 7, 10, 13,16–17 were examined in powder form; nos 6, 8–9, 11–12, 14–15 – after being embedded in "Duracryl" acrylic resin, see n. 14

** Natural azurite should be linked with the blue modelling of Mary's mantle that is adjacent to the red robe.

*** Protein varnish – original varnish, placed locally; it could have protected the layer containing organic yellow lake – probably sensitive.

Table 4a
Analysis of sample no. 12 (red in the shade part of St John the Evangelist's mantle – fig. 11)

No.	Colour and type of layer	UV	IR	IRFC
8	red glaze	purple fluorescence	grey	yellow-brown
7	red glaze	orange fluorescence, orange-brown grains	grey	yellow-brown
6	red paint layer	quenching of fluorescence	light	green-yellow
5	green, crystalline paint layer	quenching of fluorescence by copper	dark	blue
4	brown underpainting	quenching of fluorescence by mercury, tin and organic black, visible red minium grains	black, dark, light	black, yellow-brown, yellow
3	isolation	yellow fluorescence of oil	light	yellow
2	black underdrawing	quenching of fluorescence, black particles	black	black
1	white ground	yellow fluorescence of oil	light	white-yellow

Table 4b
Analysis of sample no. 12 (red in the shade part of St John the Evangelist's mantle – fig. 11)

No.	Detected elements			Pigments, binder
	Microchemical tests	Spectral analysis	SEM / EDS analysis	
8	Pb: reaction with Na_2S: blackens	Ca, Pb, Hg, Cu, Fe	Al	organic red lake, likely kermes or carmine lake?, white lead, oil
7	Pb: reaction with Na_2S: blackens		Al, P	organic red lake, likely madder lake, substrate $Al(OH)_3$, oil
6	Pb: reaction with Na_2S: blackens		Fe, Pb, C, P	natural iron oxide red, minium, oil
5	Pb: reaction with Na_2S: blackens		Cu, Pb, P	malachite, white lead, oil
4	Pb: reaction with Na_2S: blackens		Hg, Pb, P, Sn, Ca, C, Na, Al	vermilion, lead tin yellow, bone black, vegetable black, minium, *cerrusa* (white), oil
3	-		-	oil
2	-		Ca, Cu, P	bone black $Ca_3(PO_4)$ and $CaCO_3$
1	Pb: reaction with Na_2S: partly blackens amido black: partly fades (strong oil saturation)		Ca, Mg, P, Pb, Na, Si, Sn	chalk, small addition of white lead, protein glue, saturated with oil